CEBAF PROPOSAL COVER SHEET

This Proposal must be mailed to:

CEBAF
Scientific Director's Office
12000 Jefferson Avenue
Newport News, VA 23606

and received on or before OCTOBER 30, 1989

A. TITLE:

A Study of Longitudinal Charged Pion Electroproduction in D2, HE3, and HE4

B. CONTACT PERSON:

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C. THIS PROPOSAL IS BASED ON A PREVIOUSLY SUBMITTED LETTER OF INTENT

[X] YES
[ ] NO

IF YES, TITLE OF PREVIOUSLY SUBMITTED LETTER OF INTENT

A Study of Longitudinal Pion Electroproduction in D2, HE3, and HE4

D. ATTACH A SEPARATE PAGE LISTING ALL COLLABORATION MEMBERS AND THEIR INSTITUTIONS

===

(CEBAF USE ONLY)

Letter Received 10-30-89

Log Number Assigned PR-89-011

By KES

contact Jackson

CEBAF Experiment Requirements

Date Submitted 10 /26

Title & Spokesperson A Study of Longitudinal Charged Pion Electroproduction in D2, HE3, and HE4 - H. E. Jackson

Estimated total beam time (hours)	600
Electron beam energy(s) required	0.5, 9, 1.0, 1.8 GeV
Beam current(s) (µA)	30
Total µA-hours required	18000
Solid target(s) material	-
Solid target(s) thickness	-
Cryogenic target -type and length (cm)	H2, D2, ^{3}He, ^{4}He 2 cm
Power deposition in cryogenic target (Watts)	10-20 watts
Polarized beam (y/n)	n
Polarized target (y/n)	n
Power deposition in polarized target	-
Effective beam spot diameter (≥100 microns)	-
Scanned beam at target (y/n)	n
Dispersed beam (y/n)	n

Spectrometer Requirements	*e' Arm*	*Hadron Arm*
Solid angle acceptance (msr)	6	9
Momentum acceptance (FWHM %)	10	40
Momentum resolution (FWHM %)	nominal	nominal
Scattering angle (degrees)		
Minimum	20	20
Maximum	60	50
Scattering angle, uncertainty (mr)	nominal	nominal
Central orbit momenta (MeV/c)		
Minimum	500	100
Maximum	1800	500
Spectrometer settings, reproducibility,		
Central angle (mr)	2	2
Central momentum (MeV/c)	2	1
Particle identification requirements		
Rejection type (e.g. π^-/e^-)	π^-/e^-	π/e
Required ratio (e.g. 10^{-3})	10^{-2}	10^{-2}
Traceback capability required (y/n)	n	

Position accuracy along beam (mm)	nominal
Luminosity range (cm^{-2} sec^{-1})	10^{36}-10^{38}

Remarks:

October 27, 1989

RESEARCH PROPOSAL

A Study of Longitudinal Charged Pion Electroproduction in D2, HE3, and HE4

Submitted by

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ABSTRACT

We propose to study longitudinal charged pion electroproduction (in the excitation region below the delta isobar) along the direction of the momentum transfer where the charge scattering process dominates. Direct comparison of the cross section per nucleon in deuterium and the helium isotopes with the experimental value for the free nucleon will provide estimates of the strength of the nuclear pion field. A Rosenbluth separation of the longitudinal and transverse cross sections will be performed for four-momentum transfers of 2.5 and 10 fm^{-2}. If current conceptions of pion exchange currents in nuclei are correct, electroproduction will be suppressed at the lower momentum transfer and enhanced at the higher momentum transfer by the nuclear pion excess.

I. MOTIVATION

In the excitation region below the delta(3,3) the longitudinal component of charged pion electroproduction on the nucleon is viewed in terms of quasifree scattering of virtual pions into the continuum.[1,2] To the extent that such charged scattering dominates, electroproduction provides a means of probing the properties of the pion field of the nucleon. In nuclear matter the properties of the pionic field will be modified by the presence of pion exchange currents. Friman, Pandharipande, and Wiringa[3] have calculated the change in the average number of pions in nuclei which can be attributed to multi-nucleon interactions. They find a pion excess per nucleon which is slightly negative for virtual pion momenta of 100-150 MeV/c, and positive for higher values with a maximum in the region of 400 MeV/c. The magnitude of the excess is a function of nuclear binding, increasing rapidly in the light nuclei. One explanation of the "EMC effect" in deep inelastic muon scattering,[4] i.e. enhanced scattering in heavy nuclei at low values of the scaling variable, x, is an increase in the density of sea quarks in nuclear matter arising from this pion excess. However, more recent data from Drell Yan studies of antiquark structure functions in nuclei and the failure to observe a significant enhancement of the longitudinal spin-isospin response in polarized proton scattering by nuclei argue against a significant pion excess in nuclear matter. The apparent absence of an excess is a challenge to the conventional understanding of nuclear forces in terms of pion exchange and delta excitation. If confirmed in future experiments, these conclusions will require a reformulation of models of the medium and short-range properties of nuclear forces.

We propose to study longitudinal pion electroproduction in the direction of the momentum transfer where the charge scattering by the pion field dominates. In this direction, interference terms in the production cross section are negligible and a Rosenbluth separation of longitudinal and transverse cross sections can be made by means of measurements at the same momentum transfer, but different incident energies and angles. Direct comparison of the cross section per nucleon in deuterium and the helium isotopes with the experimental value for the free nucleon will provide evidence for the presence of multinucleon effects, which can be related to the nuclear pion excess.

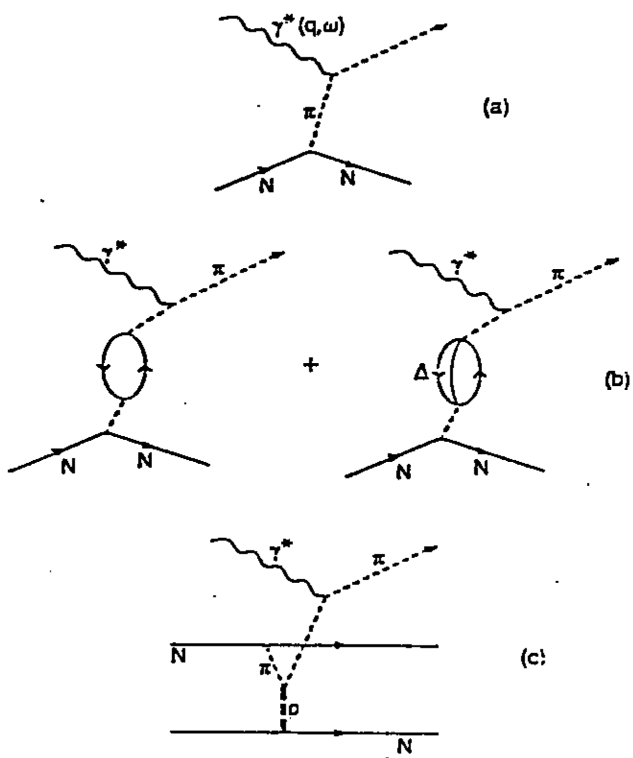

Figure 1
Electron charge scattering due to the nucleon pion field in lowest order (a) and multinucleon higher order process (b,c).

It is useful to view these effects as modifications of the elementary $n \to n\pi$ coupling in nuclear matter. The lowest order pion charge scattering for the nucleon is shown in Fig. 1a. In composite nuclei this amplitude is modified by the addition of other multinucleon processes such as those of Fig. 1b, 1c. The nucleon rescattering terms in which the pion is subsequently scattered by the photon into the continuum, can equivalently be considered as medium modifications of the pion propagator for the basic pion pole term of Fig. 1a. Ericson and Thomas[5] have pointed out that these processes can lead to an enhanced scattering for virtual pions in the region 300-400 MeV/c where Friman et al. predict an enhancement of the pion field. To account for them in electroproduction, one can incorporate explicitly the amplitudes for the multinucleon processes in the calculation of the longitudinal response of nuclei, following Ericson and Thomas. Or alternatively, one can calculate a pion-excess charge density arising from exchange currents, as Friman et al. have done, and include the charge scattering from this component of the nuclear charge density in the longitudinal response. Light nuclei such as the deuteron and ^{3}He are particularly interesting systems for which microscopic calculations of these multinucleon effects may be possible in a theoretical study of pion electroproduction.

TABLE 1

Pion excess per nucleon in nuclei (from Ref. 3).

Nucleus	$\langle \delta n^{\pi} \rangle / A$
^{2}H	0.024
^{3}He	0.05
^{4}He	0.09
^{27}Al	0.11
^{56}Fe	0.12
^{208}Pb	0.14

The magnitude of modifications one might expect can be estimated by calculating the cross section for quasifree electron scattering by the the pion excess calculated by Friman et al. The estimated pion excess per nucleon is tabulated in Table 1 for a range of nuclei. The excess rises rapidly in the "few nucleon" nuclei, so that already by ^{4}He it is approaching the value of extended nuclear matter.

A covariant calculation[6] shows that the incremental cross section due to the pion excess is of the form:

$$\delta(d\sigma) \quad \alpha \quad \left[F_\pi(Q^2)\right] \rho(\vec{p}^{\,+}_\pi,\ |\vec{p}^{\,+}_{\pi T} - \vec{Q}_T|)$$

where the pion distribution function, ρ, is a function of the light front variables[7], $\vec{p}^{\,+}_\pi$, $\vec{p}^{\,+}_{\pi T}$, and $\vec{Q}_T$. To the extent such a component can be isolated in the measurements discussed here, one can interpret the data in terms of the pion excess and compare the results with theoretical estimates. Measurements as a function of momentum transfer probe the pion excess density at different virtual pion momenta, k. The momentum distribution of the excess pions calculated by Friman et al. is shown in Fig. 2. It is negative for momenta of 100-200 MeV/c (0.5-1.0 fm^{-1}) and positive for higher values with a maximum around 400 MeV/c (2 fm^{-1}). We expect the amplitude for charged electroproduction to be enhanced in the region of positive excess and diminished at lower momenta where the excess is negative. Calculations indicate that the enhancement of the longitudinal cross section of the deuteron may be as large as 20% for momentum transfer which probe the peak of the pion excess. If the process follows the trends suggested by the calculations of pion excess, the effects in the helium isotopes should be much larger. The measurements proposed here will be possible only with high duty factor and incident beam energies of up to 2 GeV. They will only be possible with an accelerator with the characteristics of CEBAF. Energies substantially above 1 GeV are essential to probe the properties of the pion field over the full range of values of momentum, k, of interest.

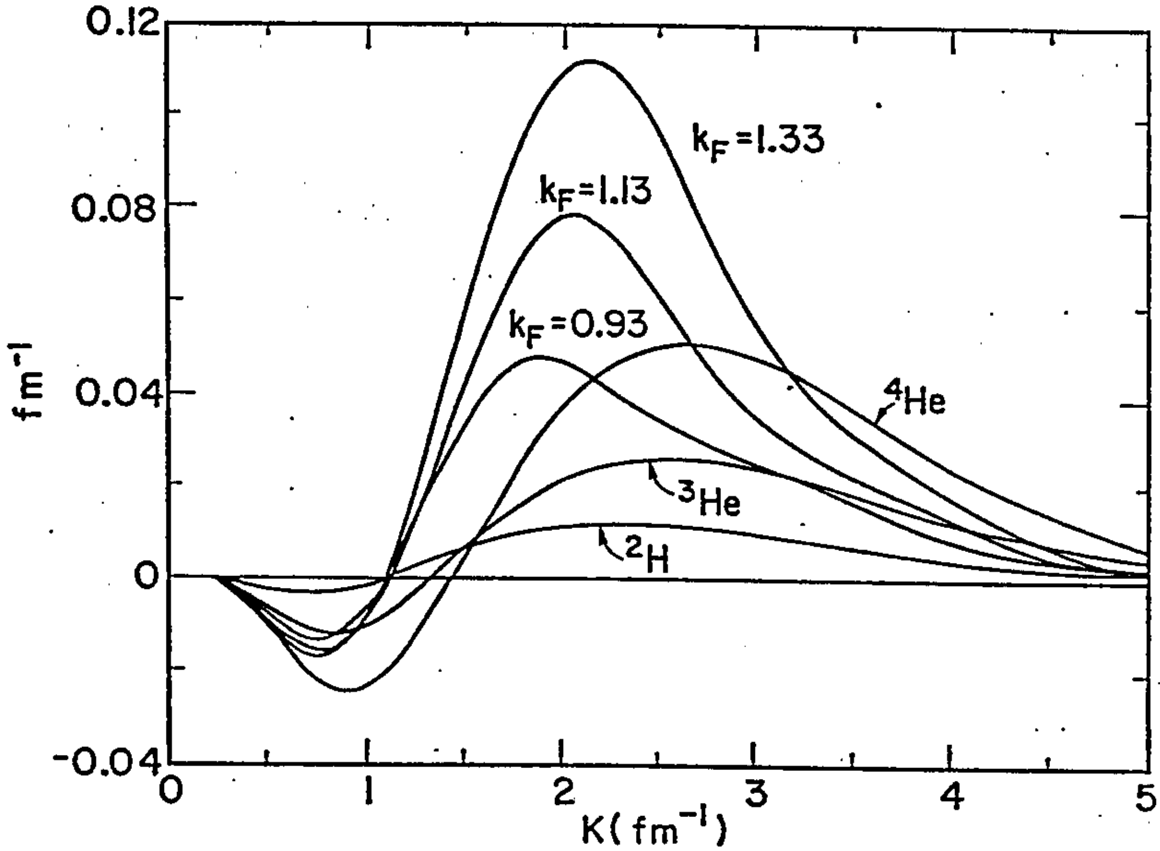

Figure 2
Values of $k^2\langle\delta n^{\pi}(k)\rangle/2n^2A$ for various systems as calculated by Friman, Pandharipande, and Wiringa. $\langle\delta n^{\pi}\rangle/A$ is the integral of this quantity of k.

II. PROPOSED EXPERIMENT

The objective of this experiment is a direct comparison of "forward angle" longitudinal pion electroproduction in deuterium and the helium isotopes with the same reaction on the free proton. We have chosen these light targets in order to minimize corrections for absorption of the emerging pions, while still providing a set of targets over which variations in the predicted effects of the pion exchange currents are large. For the deuteron and ^{3}He charged electroproduction leads to final states in which only T=1 nucleon pairs are allowed. Pion absorption is known[8] to be strongly suppressed for such configurations. In ^{4}He a large body of experimental data on pion can be used to provide reliable estimates of necessary corrections. To isolate the longitudinal cross section a Rosenbluth separation will be necessary. We propose measurements at two values of the four momentum transfer, 2.5 fm^{-2}, where the effects of the nuclear pion excess may diminish forward angle electroproduction, and 10.1 fm^{-2} where they may enhance the process. The measurements proposed are in parallel kinematics, i.e. the pion

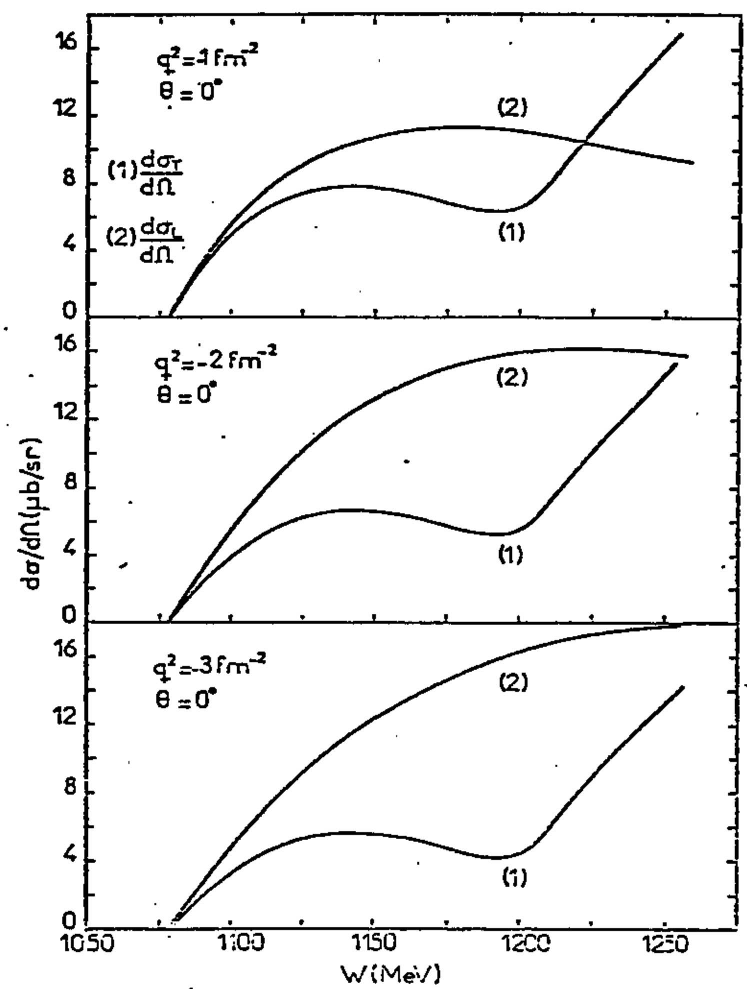

Figure 3
Longitudinal and transverse virtual photon cross sections for the forward angle electroproduction of charged pions by the proton as a function of invariant mass. From the thesis of B. Michel, Saclay 1977.

is emitted in the direction of the virtual photon. Single nucleon virtual photon cross sections for forward angle electroproduction below the delta isobar are shown in Fig. 3. The experimental conditions will be constrained to give a single nucleon invariant mass near 1160 MeV, a region where electropion production on the proton is predominately longitudinal and where the pion pole term provides the largest contribution to the cross section. The kinematics we have chosen are show in Table 2 together with estimated counting rates for a measurement with a deuterium target. These rates were determined by using a model of quasifree electroproduction on a nucleon bound in the deuteron. In the experimental configuration assumed, the scattered electrons are observed in the HMS spectrometer, and the pions in the short orbit spectrometer, SOS, in Hall C. We used solid angle acceptances of 6 and 9 msr respectively and total momentum acceptances of $p_{max}/p_{min} = 1.10$ for electrons and 1.40 for pions. The deuterium target thickness is 0.2 grams and the incident electron beam current is 30 microamps. Corrections have been made for decay losses in the pion spectrometer.

We have estimated the accidental coincidence rates by using measured photoproduction cross sections for pions to generate the inclusive electroproduction cross sections. A coincidence resolving time of 2.0 nanoseconds was assumed. The procedure was checked against inclusive cross sections measured at 740 MeV for the proton. For the luminosity we have chosen, the ratio of true to accidental coincidence rates will be about 1:1 for all of the kinematics of Table 2. This is the ratio before any constraints are made on quantities such as missing mass to suppress background. The experimental study of charged electroproduction at 645 MeV by the deuteron which we recently completed provides a benchmark for the measurements proposed here. Observations were made under kinematic conditions close to those of the measurements proposed here for Q^2=2.5 fm^{-2}.

In spite of the poor duty factor of the accelerator at Saclay (.005) and the attendant ~1:10 true to accidental ratio we were able to measure the ratio of proton to deuteron cross sections with a precision of 5%, and to observe a substantial suppression of electroproduction in the deuteron. A preprint describing this work is attached as an appendix. For the measurements proposed at CEBAF we expect the precision to be limited by systematic rather that statistical errors.

TABLE 2. Kinematics and Counting Rates

E	ω	θ_ϵ	θ_q	W	Q^2	p_π	ϵ	coin rate	e^- singles rate
GeV	GeV	Deg	Deg	GeV	fm^{-2}	GeV/c		kcph*	khz
0.5	0.3	59	23	1.16	2.5	.24	.45	0.3	3.7
1.0	0.3	22	36	1.16	2.5	.24	.88	14.6	106.0
0.9	0.46	60	30	1.16	10.1	.32	.50	0.3	3.6
1.8	0.46	23	44	1.16	10.1	.32	.89	8.7	77.9

*Kilocounts per hour. ϵ is the photon polarization parameter.

III. RESOURCES REQUIRED

This experiment does not place strong demands on the spectrometers to be used. Only moderate energy resolution, less than about 1%, is required in either arm. The HMS spectrometer would be satisfactory for the electron arm. For observation of the pion, a short trajectory instrument will be necessary in order to minimize decay losses. The short orbit spectrometer proposed for Hall C would provide an excellent pion arm. The pion detector system for this experiment should include two sections of multiwire proportional chambers, two planes of segmented plastic scintillator, and a threshold gas Cerenkov chamber interposed between the scintillator planes behind the wire chambers. A Cerenkov counter with a Freon 114 radiator at normal STP will serve to reject positrons and electrons. Requirements for beam current and energy are well within the design objectives for CEBAF. Cryogenic hydrogen, deuterium, and helium targets will be used. Beam power dissipated in the targets will be in the range of 10-20 watts. We estimate that 4 weeks of beam time will be required to carry out a productive cycle of measurements.

TABLE 3. Request for Beam Time.

Data Acquisition	$Q^2 = 2.5\ \mathrm{fm}^{-2}$ 4 targets	200 hours
	$Q^2 = 10.1\ \mathrm{fm}^{-2}$ 4 targets	200 hours
Spectrometer Check-out		100 hours
Overhead/Contingency		100 hours
		600 hours

IV. COMMITMENT OF COLLABORATORS

This collaboration has a strong commitment to the study of pion electroproduction. Members are currently engaged in a study of the same reactions in an experiment at ALS Saclay, albeit in a very much more limited kinematic range. A preprint describing this work is included as an appendix. Measurements at CEBAF will provide the first opportunity to explore the process at high momentum transfer. Resources permitting, collaborators are prepared to assist in developing the instrumentation required, and to assume responsibility for the construction of the short orbit spectrometer.

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FORWARD ANGLE CHARGED PION ELECTROPRODUCTION IN THE DEUTERON

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(Received

ABSTRACT

A direct experimental determination has been made of the ratio of the forward-angle positive-pion electroproduction cross section for a proton bound in the deuteron with that of a free proton for invariant masses of 1160 and 1232 MeV. A significant quenching of the reaction in the deuteron is observed.

PACS numbers: 25.30.Fj, 13.60.Le, 25.10.+3

To date, evidence for the modification of the structure of the nucleon in nuclear matter has been suggestive but inconclusive. Quark structure functions measured in deep-inelastic lepton scattering show some dependence on target mass.[1] The quenching of longitudinal strength observed[2] in quasifree electron scattering by medium mass nuclei has been attributed to modifications in the nucleon form factors.[3] However, studies of the kinematic scaling properties of quasifree electron scattering[4] at high momentum transfer where transverse processes dominate, and polarization transfer studies[5] show no significant differences between properties of bound and free nucleons. Pion electroproduction on nucleons in nuclei is of interest in this regard because of its sensitivity to medium modifications. Under certain kinematic conditions, the longitudinal component can probe directly the charge distribution of the nuclear pion field. The exchange of pions by bound nucleons may modify that pion field. Friman, Pandharipande, and Wiringa[6] have calculated the pion excess in nuclei which results from multinucleon processes. They find a pion excess which is slightly negative for virtual pion momenta of 100-200 MeV, and positive for higher values with a maximum around 400 MeV. One explanation of the "EMC effect" in deep inelastic lepton scattering by heavy nuclei is an increase in the density of sea quarks in nuclei[7] associated with this pion excess. Ericson and Thomas[8] have pointed out that pion-exchange currents can produce enhanced electron scattering by virtual pions in the region near 400 MeV where Friman et al. predict an enhancement of the pion field. Multinucleon processes such as delta-nucleon scattering and delta absorption may also modify electroproduction amplitudes through their effect on the propagation of the delta in nuclear matter. Simple pion rescattering, if sufficiently strong, can also distort production amplitudes.

To explore the use of pion electroproduction as a probe of such processes, we have performed a series of measurements on hydrogen and deuterium. The deuteron was chosen because, as the simplest nuclear system, it is a natural test case for any nuclear model. Observations were made for π^+ production on both targets for two values of the photon-nucleon invariant mass, W=1160 and 1232 MeV. π^- production on deuterium was also measured for W=1160 MeV. The kinematics corresponding to W=1160 MeV were chosen, because for this value of W electroproduction on the proton is predominately longitudinal[9] and quasifree scattering by virtual pions (the pion pole term) makes the largest contribution to the cross section. For the second kinematic configuration, which corresponds to W=1232 MeV, the amplitude for delta-production is enhanced. In both cases, the physics issue addressed is the extent to which the basic quasifree nucleon reaction is modified by the nuclear binding. The choice of the deuteron offered the advantage of use of a single cryogenic target for the two measurements. Because of the identical geometry, a direct comparison can be made of electroproduction on the proton in the deuteron to that of the free proton without the systematic errors common in absolute measurements. The similarity in the scattered-particle spectra for the two targets cancel any systematic effects on the ratio of the cross sections which are related to detector response and pion decay. Except for small corrections, the ratio of deuterium to hydrogen cross sections can be determined from the knowledge of the incoming charge, the target density, and the measured counts, exclusively.

For all measurements, the incident beam energy was 645 MeV and the electron scattering angle was 36°. Electrons were observed in the ALS 900-MeV spectrometer and coincident pions in the ALS 600-MeV spectrometer[10] which was set at 34°, as close as geometry permitted to the direction of the q-vector. In the kinematics corresponding to W=1160 MeV the virtual photon is emitted at 30°. A trigger in the pion arm was determined by coincident scintillators placed to require traversal by all charged particles of a gas Cerenkov counter which was used in anticoincidence to suppress contributions from scattered electrons or positrons. The combined solid angle for the two spectrometers was evaluated by means of a Monte-Carlo calculation that utilized their measured magnetic properties and included the effects of pion decay in the particle tracking. The missing mass spectrum observed for the proton in this configuration is shown in Fig. 1. The spectral shape for the proton provides a measure of the effect of continuum radiative processes. Determination of the absolute cross section provided a check on the spectrometer acceptances used in the data reduction and on the procedures used to correct pion decay in flight and radiative processes. We measured a pion production cross section for the proton at W=1160 MeV of $d^3\sigma/d_e\Omega d_e E d\Omega_\pi$=46±3 picobarns/sr^2 MeV. This result can be compared with that of Bardin et al.[9] and the phase shift analysis of von Gehlen[11] through the virtual photon cross section in the center-of-mass which is free of extraneous kinematic dependences. Using the notation of Ref. 12, we measure $d\sigma/d\omega$=9.7±0.5 microbarns/sr for the virtual photon cross section at W=1160 MeV. Interpolation of the data of Bardin et al. to our kinematics gives 10.7±1.0 microbarns in good agreement. The value predicted by the phase shift analysis is 7.1 microbarns. The discrepancy here may arise from the lack of data between the pion threshold and the delta which would constrain the phase shifts in the kinematics of our experiment.

The missing mass spectrum measured for the deuteron is presented in Fig. 1. Within the accuracy of the data, the shape agrees well with a calculation of quasifree electroproduction on a nucleon described by a standard deuteron wave function including the D-state component.[13] Similar conclusions pertain to the line shape observed for W=1232 MeV. For the ratio of the deuteron cross section for positive pions integrated over missing mass to the proton production cross section, we find:

$$R = 0.80 \pm 0.05 \qquad W = 1160 \text{ MeV}$$
$$R = 0.75 \pm 0.07 \qquad W = 1232 \text{ MeV}$$

We have also measured the π^+/π^- ratio for deuterium for W=1160 MeV and find 0.94±0.11. The error in this value results primarily from the more limited statistics of the π^- measurement. The deuteron/proton ratios are of particular interest. The decrease of the deuteron cross section compared to the value for a free proton in the same kinematics may signal significant nuclear medium effects.

Forward angle quenching may arise from modifications in the $n \rightarrow n\pi$ coupling by multinucleon processes in the bound system. Direct pion charge scattering, shown in Fig. 2a, is believed to be important at forward angles where t-pole processes are favored.[9] In a composite system, this amplitude is modified by the addition of other multinucleon processes such as those of Figs. 2b and 2c. The nucleon rescattering terms in which the pion is subsequently scattered by the photon into the continuum, can equivalently be considered as medium modifications of the pion propagator for the basic pion pole term of Fig. 2a. As mentioned above, Ericson, Thomas,[8] and others have speculated that such higher order processes can enhance the longitudinal response of the nuclear system in the pion momentum range of (2-3 fm^{-1}). Such an enhancement can be interpreted as a pion excess arising from the exchange processes. At the lower virtual pion momenta probed at our kinematics, constraints on the final states available to the neutron pair can suppress the reaction. This suppression is the origin of the negative pion excesses which are calculated by Friman et al.[6] for pion momenta near 1 fm^{-1}. The forward angle suppression of electroproduction indicated in our results, particularly at W=1160 MeV may provide the first experimental indications for a significant change in the pion content of nucleons bound in nuclei. The suppression at W=1232 MeV, where the amplitude for delta production is strongest, may have its origin in delta-nucleon final state interactions.

Other possible sources of suppression at forward angles include pion absorption and simple Fermi broadening of the forward angle peak. Pion absorption should not be significant. Recent results on studies of pion absorption in light nuclei[14] imply that absorption should be weak for π^+ production on the deuteron since the final nucleon state is T=1. A comparison of the photoabsorption cross section for the deuteron[15] with the photopion cross section provides an upper limit of 5% for pion absorption. In a plane wave impulse approximation calculation,[13] which includes the Pauli effect on the final nn state, it is found that R=0.92 for both values of W. It remains to be established whether a combination of pion absorption and kinematic broadening together with Pauli blocking of final states can explain our observations. It is clear that a systematic study of forward angle electroproduction will be necessary to establish quantitatively the sensitivity to the pion content. Rosenbluth separations will be needed to isolate the longitudinal cross section in which pionic charge effects are expected to be most prominent. Study of the dependence of the cross section on momentum transfer will be needed to probe the dependence of any enhancement or suppression on virtual pion momentum. Measurements for a number of light nuclei will provide useful data on the sensitivity of longitudinal electroproduction to nuclear binding effects.

In summary, we have made the first direct experimental comparison of charged pion electroproduction by a nucleon bound in a nuclear system with that of the free nucleon. Our data provide strong evidence that, even in the weakly bound deuteron, multinucleon processes alter the electroproduction amplitudes in the forward direction. More detailed studies of the reaction as a function of momentum transfer and target mass will be needed to establish its sensitivity to properties of the nuclear pionic field.

We are grateful to F. Coester, J. M. Laget and T.-S. H. Lee for extensive discussions of the Theory of pion electroproduction, and to A. Godin and co-workers for their efforts in operating the hydrogen-deuterium cryogenic target. This work supported in part by the U. S. Department of Energy, Nuclear Physics Division, under contract W-31-109-ENG-38.

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FIGURE CAPTIONS

Fig. 1 Missing mass spectra for an invariant mass of 1160 MeV. The incident electron energy is 645 MeV and the electron scattering angle is 36 degrees. The open points represent data taken with the pion spectrometer centered on the peak of the pion distribution. The crossed points in the deuteron spectrum were taken with the central momentum of the pion spectrometer lowered by 20% in order to observe the strength at higher missing mass. The data have been corrected for the missing mass acceptance. No corrections have been made for radiative processes. The curve for the hydrogen data is a radiation broadened monoenergetic peak. The dotted curve in the deuteron data is the radiation-broadened shape calculated for quasifree electroproduction on the proton bound in the deuteron with the same integrated yield as the proton. The solid curve has been renormalized by 0.8 to fit the data.

Fig. 2 Electron charge scattering due to the nucleon pion field in lowest order (a) and multinucleon higher order charge scattering processes (b,c).

ANL-P-19,662

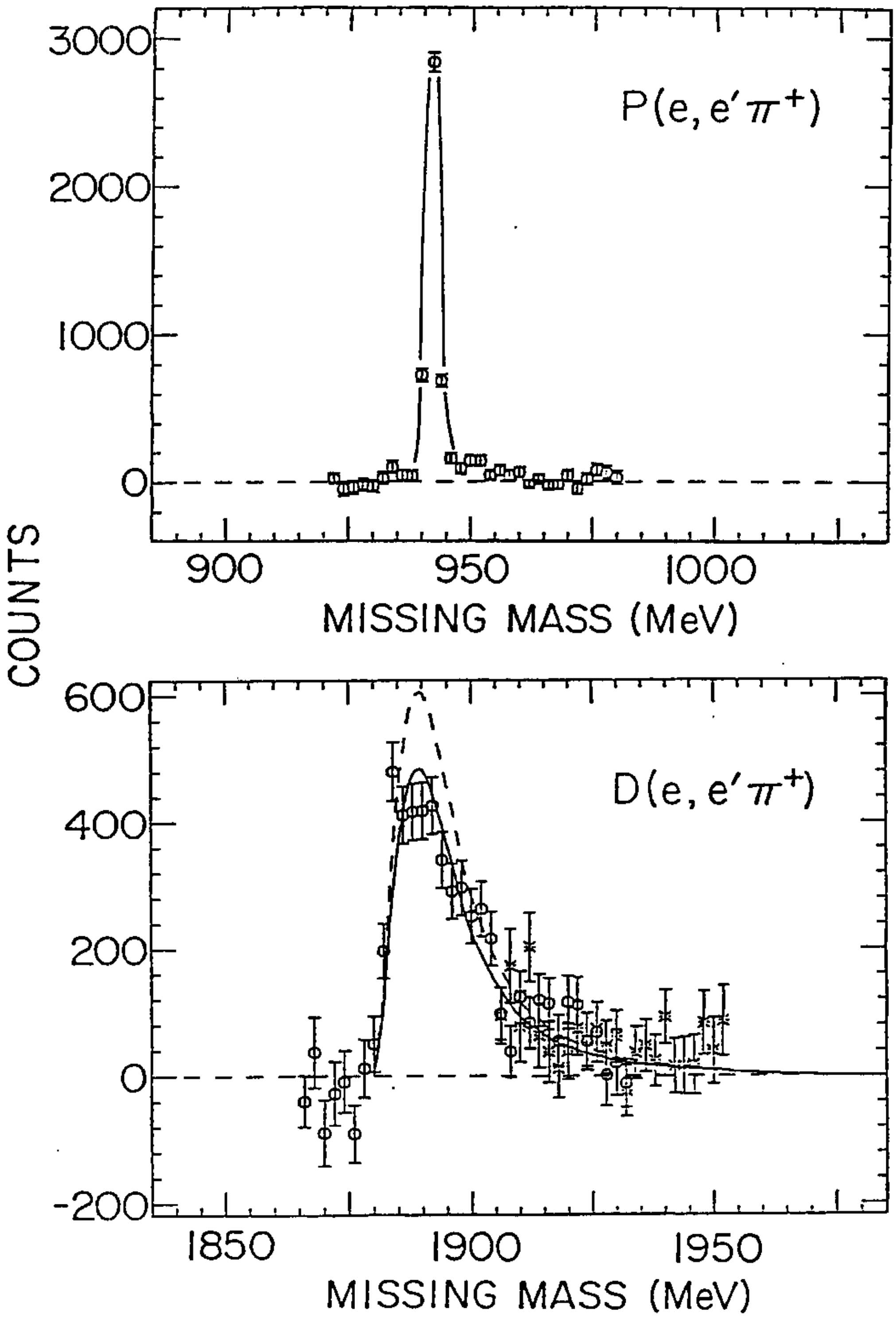

Fig. 1

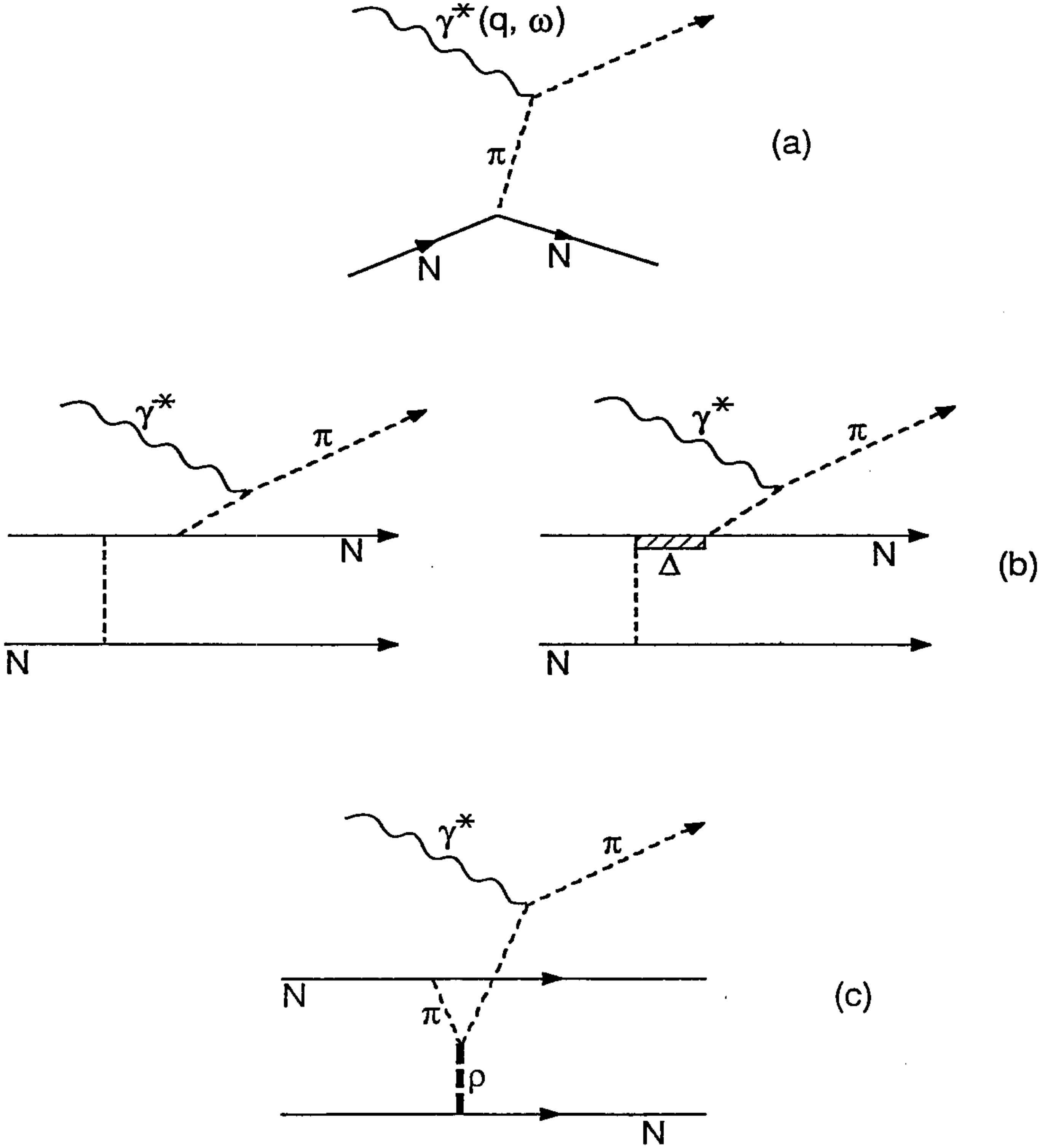

Fig. 2

Continuous Electron Beam Accelerator Facility
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Proposal Number: PR-89-011

Proposal Title: A Study of Longitudinal Charged Pion Electroproduction in ^{2}D, ^{3}He, and ^{4}He

Spokespersons/Contact Persons: H. Jackson

Proposal Status at CEBAF:

Conditional approval.

Dirk Walecka

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Scientific Director